GAS IN INDUSTRY

OCTOBER 1960

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FEATURES

FROM GASWORKS TO GLASSWORKS—the uses of gas at Key Glassworks by Eric Ford.

GAS AT BIG FACTORY EQUIPMENT EXHIBITION

'FIVE TOWNS' JUBILEE STRONG GAS EXHIBIT

INDUSTRIALISTS SEE HOW GAS CAN HELP

METAL FINISHING
By S. Heywood

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Editorial

Gas for metal finishing

METAL finishing is one of those processes which demand the utmost care in its operation, if a large amount of spoilt work is to be avoided. However great has been the care taken in the manufacture of the article, however carefully the design and materials of construction have been chosen and the workmanship supervised, a faulty finish will immediately render it useless. The aim of the metal finishing process must therefore be to turn out the greatest number of saleable products attractively finished at the lowest cost. The attractiveness of the finish, the standard of which is now looked upon as a sales promotion aid, must be considered of equal value with the ability of the surface to resist corrosion and disintegration.

Metal surface finishing is a two-stage process: The efficient cleaning of the original material to rid it of grease and scale (generally mill scale or that caused by atmospheric oxidation), and the application to the chemically pure surface of some form of protective coating. Apart from conventional painting, this latter process generally takes the form of lacquering, enamelling or galvanising, all of which operations require the article to undergo some sort of heat treatment.

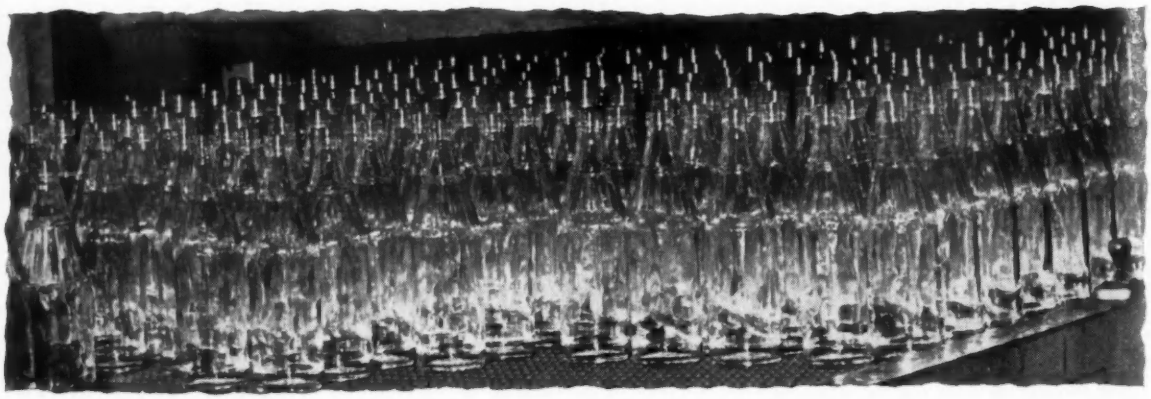
For this purpose gas has been found to be extremely efficient and the paper we are publishing this week, 'Metal Finishing' by Mr. S. Heywood, Industrial Engineer of the West Lancashire Group, the North Western Gas Board, explains in some detail how gas does indeed assist in furthering the aims which we have outlined. Whatever the fuel used, the heat treatment will be either radiant or convector, depending on the shape of the work to be treated. For instance, radiant heating was proving itself unsatisfactory in the treatment of copper wire but when it was discovered that the length: width ratio of the material treated, above which this form of heating was known to be unsatisfactory, was being exceeded, convector heating was substituted with excellent results.

It is unlikely that a change of this kind could have been made so quickly and so effectively using any other fuel than gas. Mr. Heywood describes in some detail the heat treatment of lacquered and painted surfaces in infra-red tunnel ovens. Provided the weight: surface ratio is satisfactory and the conductivity of the material treated is reasonably high, the temperature of the article will rise to the 'curing' temperature almost in a matter of seconds.

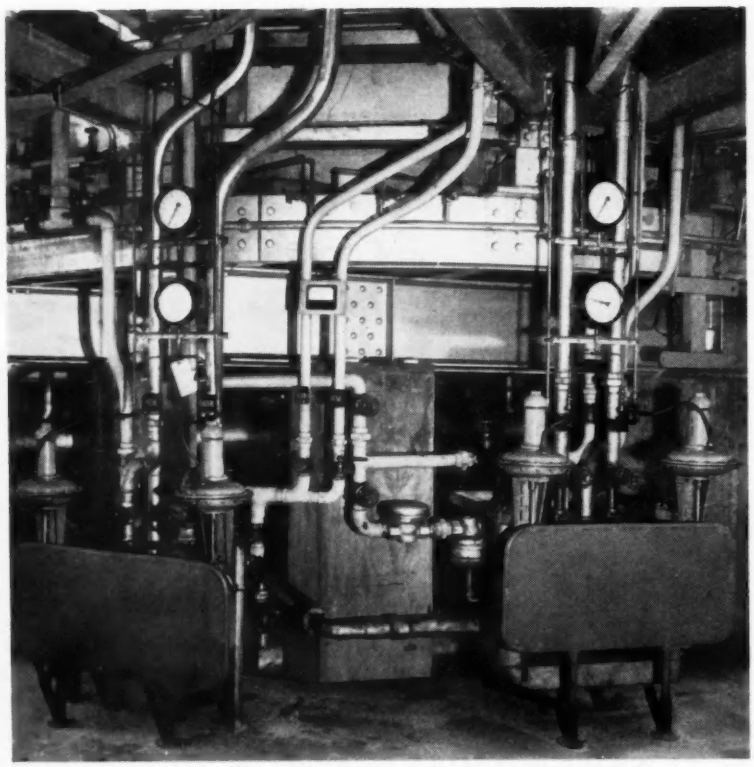
Vitreous enamelling is an important finish for a variety of kitchen equipment. Since the temperature of heat treatment for this process is a good deal higher, Mr. Heywood recommends gas-fired Jetube heating. This has all the advantages of the muffle furnace adapted to a continuous tunnel oven. Uniform heating is easily accomplished without contamination from the products of combustion.

The advantages of any of the refined fuels in common use by industry can be easily and efficiently concentrated in the modern gas-fired furnace or oven to carry out each process needed by metal treatment or finishing under continuous processing conditions. Ease of control, flexibility of temperature range and the least possible maintenance to the combustion furnaces and appliances are other important features, in all of which gas as a fuel excels.

From GASWORKS . . .



. . . to GLASSWORKS



Gas supply arrangements below one of the melting furnaces at the Harlow New Town works of Key Glassworks Ltd. Gas is used to bring these furnaces through the early stages of warm-up after a close down and before the normal oil heating procedure commences.

ERIC FORD SHOWS HOW GAS HELPS TO CREATE 10,000,000 CONTAINERS A WEEK

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THE annual output of the glass container industry in the United Kingdom is today somewhere in the region of 4,000 mill. containers. Key Glassworks Ltd., Harlow, is one of the leading firms contributing towards this vast total. The gas industry also plays its part in the production of these millions of high-grade glass containers upon which the community has come to depend.

Despite the introduction of new materials into the container industry, glass is still the best and most economic material for practically all

GAS-FIRED EQUIPMENT IS VITAL FOR SUCCESS

applications. In fact, the demand for glass containers continues to grow to such an extent that the productive capacity of the manufacturers of these containers is fully extended to meet it.

That this should be so will be evident from a glance at the display shelves in any up-to-date self-service store which will soon reveal the extraordinary variety of shapes in which glass containers are produced and their widely differing contents. For glass is the ideal container for all liquids, powders and solids, from milk and soft drinks to jams and pickles, from cleaning materials and polishes to hair creams and beauty preparations, and from potted meats and sauces to proprietary medicines and lotions.

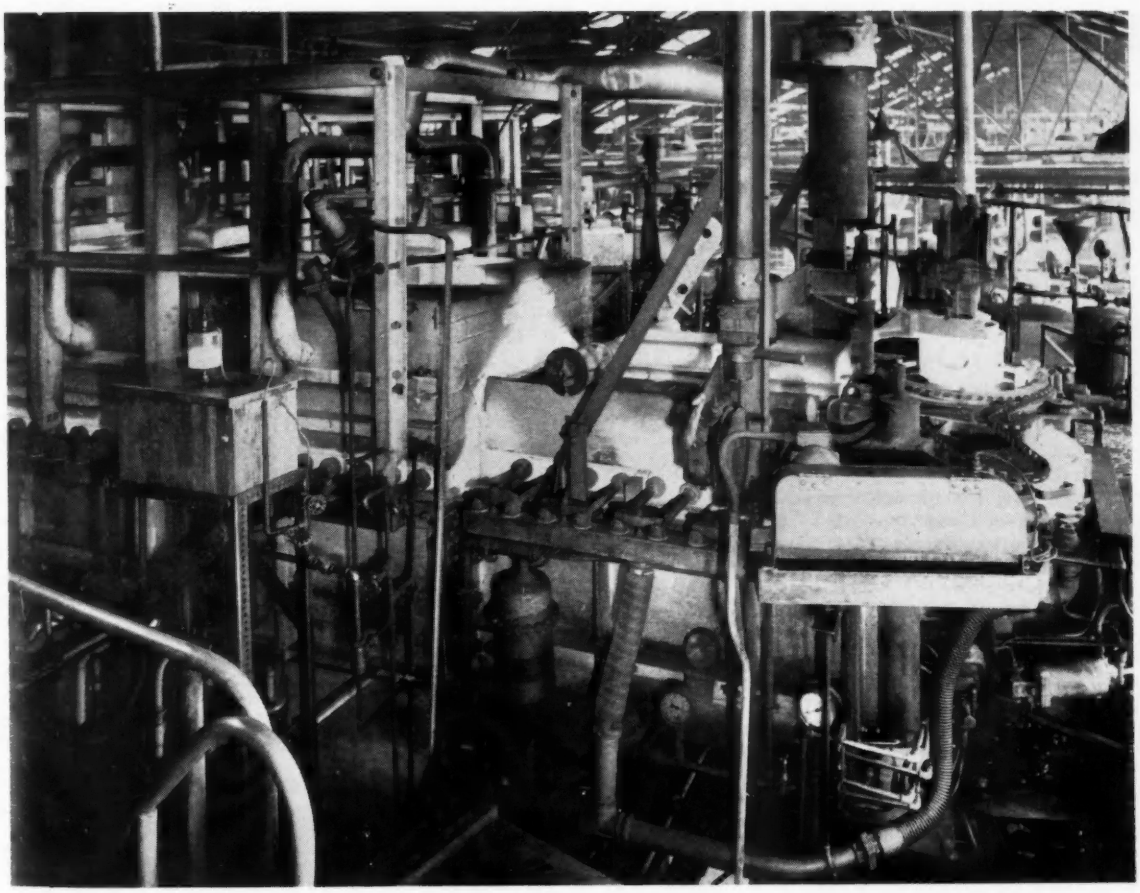
Although the most obvious uses for glass containers are found in the consumer goods sector of the economy, they are at least equally necessary throughout industry wherever a safe and reliable container is required for the thousand-and-one oils, pastes, powders and other materials required in production, maintenance or servicing.

In view of the wide popularity of the ubiquitous glass container it is perhaps hardly surprising that the vast numbers required can only be produced by the application of automatic methods of production. This is certainly the case at the Harlow factory of Key Glassworks Ltd., where the staggering total of 10 mill. glass containers a week are produced by methods which can accurately be described as approaching complete automation.

Heat plays a vital part in the glass manufacturing process, being required to fire the huge furnaces where the constituent materials are melted, and for annealing the containers after they leave the moulds. The accurate application of heat is also necessary at points between these two applications. At Key Glassworks Ltd., all three main forms of heating are employed, namely gas, oil and electricity, and each has been carefully selected for the duty in which it gives optimum efficiency.

An idea of the importance which gas has in the production process at Key Glassworks Ltd., can be gauged not only from the fact that it is used in some of the most vital sections of the container-making operation, but also that the average annual gas load supplied to the plant by the Tottenham Division of the Eastern

While the molten glass passes along the feeders, gas-fired burners (shown here) fire into the refractory-lined channel. The molten glass moves along the channel from left to right, to be shot downwards at the bottom right-hand side of the picture into the container-making machine below.



In these moulds the molten glass is formed into bottles and containers of many different shapes. After coating in graphite, the moulds are heated in a gas-fired oven.

Gas Board is very considerable indeed.

Founded in 1908 as the result of an amalgamation with a firm dating back to 1875, this plant moved to Harlow in 1954, where it occupies a site of some 26 acres and employs about 1,200 workers. The main glass-fronted office block through which the visitor approaches the plant presents an immediate impression of careful and tasteful design of the type one expects in a New Town factory. The manufacturing plant has been laid out with great care to ensure a balance between the stringent demands of the manufacturing process and the need for the utmost economy of space.

It is not always appreciated by the layman that there are many different kinds of glass, depending on the duties it is required to perform. The use to which the glass is to be put affects the materials of which it is made; general purpose glass, of the type used for bottles and other containers, is known as soda lime glass for which the main ingredients are sand, limestone and soda ash.

These materials arrive at the works by rail (for which purpose the Company has its own railway sidings) and in some cases by road. The materials are off-loaded through gratings at road level and automatically transferred to storage hoppers which feed the batching plant. It is most important that the raw materials should be mixed in the correct proportions for the type of glass being produced, and both the weighing and mixing at Key Glassworks Ltd., are performed mechanically.

To this mixture, known to the trade as 'batch,' a certain proportion of broken glass (or 'cullet') is added before the whole mixture is fed to the furnaces for melting. The approximate proportion of broken glass is 16% and this is mainly obtained from finished bottles which have not passed the severe inspection to which they are subjected before leaving the factory.

Melting takes place in four 'tank' furnaces, each of which produces from 60 to 100 tons of glass a day. The operation of these furnaces is continuous, 'batch' being automatically fed in at one end by mechanical feeders as the molten glass is drawn off at the other. The operating temperature of the furnaces is of the order of 1,540°C. and the furnaces are kept alight continuously.

Early stage fuel

Oil is the fuel used for firing these furnaces but gas is used in the earlier stages of bringing a furnace up to temperature from cold, after a shut-down for maintenance or repair. It is interesting to note that such shut-downs only take place every two and a half or three years so that these furnaces are kept in action, day and night, for very long periods.

When a furnace is brought back into production, the complete warm-up from cold takes about a fortnight, but during the first week of this period the alternative gas burners will bring the furnace up to approximately 1,000°C., giving better control during this important stage.

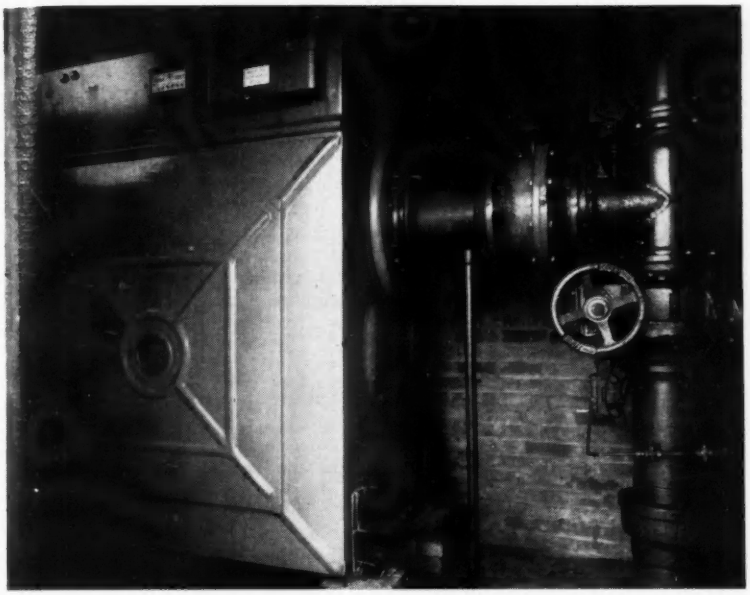
While the oil burners are firing into the furnace, the gas burners are removed from their supply pipes and the pipes themselves swung clear to give room for the service of the oil burners. Gas burners are fitted to their service pipes and moved into position when the alternative gas-firing arrangements are in use for the warming-up procedure. The change over from firing by gas during the initial stages of heating up to oil firing as required in normal production, is carried out progressively over a period of two or three hours.

Success point

Considerable advantages are obtained from this use of gas as an alternative source of heat for the furnaces, but it is in the next stage of production that gas-fired equipment is vital for success. This is the point where the molten glass, having left the furnace, moves along a 'feeder' towards the intricate bottle-making machinery.

There are altogether 23 feeders supplying as many machines which are capable of making the extraordinary variety of containers which annually leave the Key Glassworks Ltd. plant. The typical feeder is a refractory-lined channel 175 in. long, 16 in. wide and 8 in. high. The feeder must connect

One of the automatic bottle-making machines. The 'gob' of molten glass is shot down from the feeder above into the moulds. The completely formed bottle is then taken from the mould mechanically and placed on the conveyor for transfer to the annealing 'lehr'. Gas is used to maintain the temperature of the molten glass during the time it is moving from the furnace, via the feeder, to the bottle-making machine. It is also used along the conveyor to the 'lehr' to prevent bottles cooling too rapidly.



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Through this 25,000 cu.ft. per hour meter (left) the gas supply flows into Key Glassworks Ltd. The machine (below) delivers 'gobs' of molten glass at the required weight, speed and temperature. The gas burner manifolds can be seen in the foreground.

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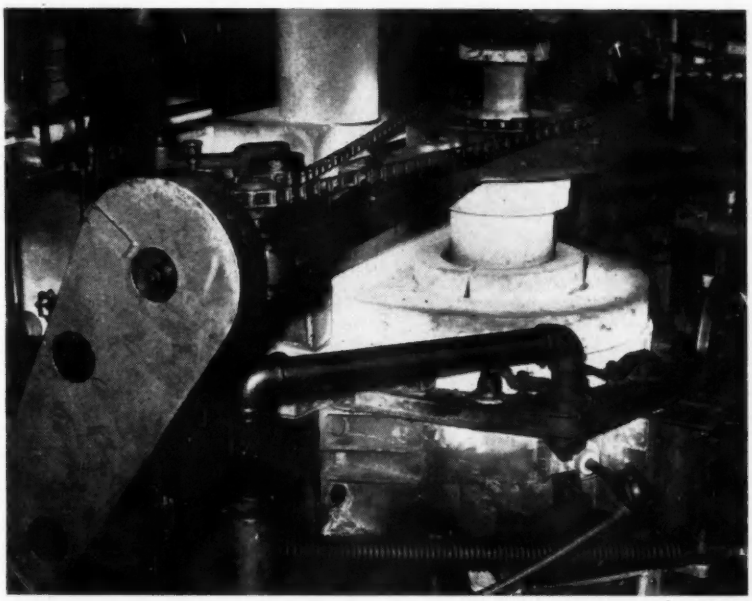


the exit point of the furnace with the container machinery.

Leaving the furnaces at upwards of 1,250°C., the molten glass would cool rapidly as it passed along the feeders unless arrangements were made to maintain the required temperature. It is not only necessary that the molten glass shall be kept hot during this stage, but it must be kept at a particular temperature, depending on the type of container which is being produced in the machine supplied by the feeder.

Air blast burners

In order to maintain the molten glass in the feeder at the required temperature, a series of air blast burners are fitted on each side of the feeder. The temperature desired will range from 1,000°C. to 1,200°C., depending on the size of the container being made. The larger bottles require the lower temperatures. As the bottles and other containers made by Key Glassworks Ltd. range from 2 oz. to 40 oz., the temperature requirements in the various feeders can vary widely.

It is an interesting fact that more gas is required to heat the feeders when, for any reason, bottle production has been temporarily stopped than when work is in full swing. This, of course, is because under normal working conditions the molten glass flowing from furnace to machine carries a good deal of heat with it from the furnace, whereas when this source of heat is stopped more gas must be burnt to maintain the temperature of the feeders.

Once the temperature of the glass in a particular feeder supplying a machine which produces a bottle of a certain size has been determined, it is vitally important that that temperature should be maintained within very close limits. Gas-fired equipment is able to provide this close control, in conjunction with the appropriate automatic temperature recording/controlling equipment. It has been found in practice that the temperature of the gas-heated feeders is maintained steadily at the required point and, in any case, the variation is never more than plus or minus 2°C. Compared with other forms of heating in this particular application, it is claimed that gas is more satisfactory, especially in the case of the larger bottles and containers.

One of the reasons why temperature control is so vital at this stage is that the viscosity of the molten glass entering the machine from the feeder must be constant. Overall control of the process is in the hands of the Company's laboratory staff. Once the required temperature has been attained, the maintenance of it is automatic. An important problem arises when it is desired to change over from producing one type of container to another on the same machine.

As already seen, the change in the temperature of the glass in the feeder may have to be quite considerable if the change-over is from a small to a large container or vice versa. Although such a change is technically

possible, obviously it is advantageous from the point of view of changes in temperature if all the containers produced on a particular machine are of approximately the same size, so that no drastic changes in the temperatures of glass in the feeder are required. In general, the Company is able to achieve this by very careful production control and forward planning. It is possible to keep some feeders supplying machines producing a similar product more or less continuously, such as, for example, certain makes of soft drink containers. Where changes have to be made which involve large temperature variations, the changes are accelerated by the temperature installations which automatically adjust the gas burners.

Change over time

If it is necessary to change over to a different type of container, the average time for the task is just under two hours, covering the removal and replacement of certain moving parts and the warming up procedure.

Container-making machines in common use today fall into two main types, using either the suction or the feeder principle. In the suction principle, a measured quantity of molten glass is sucked into a preliminary mould, known as a 'parison.' It is then transferred to a second mould in which it is blown out pneumatically to its final form.

Machines employing feeders on the other hand, receive a charge of molten glass, known as a 'gob,' which is extruded through an orifice at the end of the gas-heated feeders already described. This 'gob,' which is of precise weight for the container in question, is quickly dropped down guiding chutes into a parison mould from which it is transferred to the finishing mould. These are the types of machines which are employed at Key Glassworks Ltd.

Gas-fired oven

Gas is used in connection with the preparation of some of the parts of the container-making machines, such as the all-important moulds and the scoops down which the 'gob' slides into the mould. This delivery equipment is coated in the Company's own workshops with graphite which is fired on in a small general-purpose gas-fired oven which, incidentally, was also constructed by this enterprising Company.

Key Glassworks Ltd. also make some of their own moulds, the design of which is vital to the success of the container - making process. The moulds receive the molten glass at elevated temperatures and, with some of the containers, the design has to be quite intricate. All new moulds are coated with graphite which is burned on in the Company's gas-fired oven. Another ancillary application of gas is in the pre-heating of new refractories in the feeders when refractory material has to be replaced.

After the 'gob' of glass has been shot into the mould (the speed of the downward movement justifies this description) it is rapidly shaped by air pressure into the final form of the container. The mould opens and the formed container, now in semi-rigid form, is taken from the mould mechanically and placed or guided on to an endless belt for transfer to a 'lehr' for annealing.

Annealing is necessary to relieve the stresses set up during the hot working of the glass; if allowed to cool naturally after forming such stresses, the containers might tend to crack or shatter in actual service. Hence the necessity for annealing, which calls for temperatures of the order of 520°C. for periods up to 15 minutes.

At Key Glassworks Ltd. the 'lehrs' in which annealing takes place are electrically heated, but gas is used to control the temperature of the ware as it proceeds along the conveyor belt from the forming machine to the mouth of the 'lehr'.

Not too high, low

This is a matter of great importance because the bottles and other containers leave the moulds at temperatures of about 680°C. and during the ensuing journey to the 'lehr' the temperature must not be too high (for the containers would tend to stick together) nor too low (in which case the containers might crack.).

In order that the containers shall reach the entrance of the annealing 'lehr' at the right temperature, calculations are necessary involving the speed of the conveyor belt and the amount of heat applied. Gas is conveyed along copper piping and burns through holes sited at convenient points along the pipe. The entrance to the 'lehr' is provided with a gas curtain.

From the hot portion of the 'lehr' the containers undergo a lengthy cooling process, which may take as long as 60 minutes, before they are inspected prior to despatch. All containers are very closely examined for size and quality and any which fail to pass this severe scrutiny are rejected and broken up for use as 'cullet'. So seriously is the inspection routine taken at Key Glassworks Ltd. that the Company holds its own training courses for inspectors.

To pack and despatch the finished containers to customers in all parts of the country, as well as handling a sizeable export business, is in itself a considerable undertaking, particularly when it is remembered that containers leave the Key Glassworks Ltd. production line at the rate of about 10 mill. every week. Very careful use is made of all kinds of mechanical handling equipment in dealing with these vast quantities of cases. The amount of man-handling is kept at a minimum, thus considerably easing work-load on the firm's staff.

Co-operation

Similar consideration to staff is shown in the excellent welfare facilities.

When installing and maintaining gas-fired equipment of the size and range of the installations at Key Glassworks Ltd., close co-operation is required between the firm's engineers and the industrial officers and staff of the Authority which supplies the gas. Like most efficient firms, Key Glassworks Ltd. has played a major role in the design, construction and installation of much of the gas-fired equipment, adapting the standard products of supplying firms where necessary.

In all this work, and particularly in the installation and design of the supply lines and other ancillary equipment, the Company generously acknowledges the great help it has received from the Tottenham Division of the Eastern Gas Board.

Installations

The installations supplied and fitted by the Board have included an 8-in. service pipe, a 25,000 cu.ft. meter, two 20,000 cu.ft. per hour capacity Keith Blackman boosters, and associated pipework, by-passes and controls. Altogether, Tottenham Division staff have installed some 300 ft. of 8-in., 300 ft. of 6-in. and 400 ft. of 3-in. pipe.

Stand designers receive awards

THE results of the competition to find the best 'selling designs' for two stands at the Modern Homes Exhibition to be held in the Kelvin Hall, Glasgow, this month, have been announced.

The prizes were presented by Mr. A. McFadyen, Sales Controller of the Glasgow Division of the Scottish Gas Board, at the Board's offices in Glasgow. The first prize of £150 was won by Mr. J. W. Cresswell of Hampstead, an employee of Sir Basil Spence in London. D. Vane & Partners of Canterbury gained the second prize of £75, and the third prize of £10 was awarded to Mr. K. Langlois of Welwyn Garden City.

MANCHESTER'S LARGEST - EVER INDUSTRIAL SHOW . . . AND —

Gas-fired exhibits make big appeal

Gas-fired equipment was prominently displayed and attracted attention on many stands at the Factory Equipment Exhibition, which occupied 150,000 sq.ft. of the specially enlarged exhibition hall at Belle Vue, Manchester, from September 21 to October 1. The Exhibition, the largest industrial show ever to be held in Manchester, was sponsored by the Manchester Chamber of Commerce, the Financial Times and Industrial Equipment News, and was organised by Industrial and Trade Fairs Ltd.

AMONG more than 200 exhibitors at the Belle Vue Factory Equipment Exhibition, Manchester, were many names well-known in the gas industry, including firms producing gas-fired equipment for process work, space heating and catering.

Those producing gas-fired equipment for process heating included **Dowson and Mason Ltd.,** well-known as the manufacturers of all types of industrial furnaces. The Company is now completing a contract for the largest bogie furnace in the world.

This is being supplied to a well-known engineering company in the North-East and has dimensions of 85 ft. × 18 ft. × 18 ft. It is designed for a load of some 200 tons.

Overseas work

This Company is equally well-known in the overseas field, and recent contracts include the supply of a number of furnaces for such duties as stress relieving, plate heating and annealing for the great new integrated steelworks at Durgapur, India, which is being built by a consortium of 13 British firms.

Considerations of space prevented **Dowson and Mason Ltd.** (and other firms) from exhibiting examples of their larger installations, such as tempering, stress relieving, annealing, normalising and hardening furnaces, except in the form of photographs and models.

Equipment on show on the stand included furnaces for heating pipes and bars for bending and for heating knife blade blanks and similar small material for forging. A range of 'Target' gas burners, suitable for many industrial applications, was also displayed.

J.L.S. Engineering Co. Ltd., well-known for the design and manufacture of their patented air circulating ovens, featured a pictorial display of their products, which are custom-designed for each application. Gas-fired ovens and furnaces for temperatures up to 850°C. are designed for such operations as heat treatment, stoving, curing and drying. J.L.S. air circulating furnaces range from small batch-type units for general workshop heat treatment to large continuous 'lehrs' for annealing glassware.

Gas continues to hold its own as an ideal medium for factory and office heating, as was demonstrated by the equipment on show at Manchester. This included the well-tried range of heating equipment produced by **Harris Engineering Co. Ltd.** One of the Company's latest developments is the Harris 'Wellsway' Mark 2 flued gas convector heater, in which the products of combustion are vented to outside atmosphere.

The 'Wellsway' is rated at about 30,000 B.t.u's per hour output and is particularly suitable for heating factories, canteens, offices and other buildings. When fitted with thermostatic control, it is an economical and effective method of space heating.

Wall-mounted heater

Other exhibits shown by this firm included their well-known indirect gas-fired unit heater, a standard installation of which very many have been sold. The Company also manufactures and markets a range of direct gas-fired unit heater and a newly-styled wall-mounted radiant heater.

Powell Duffryn Modulair Ltd. have recently announced a new addition to the range of Dravo 'Counterflo' space heaters. This space heater, which can be gas-fired, incorporates a stainless steel combustion chamber, giving rapid heat gain with no preliminary warm-up period due to the absence of refractory lining. Flue gas travel is four-pass to enable the maximum available B.t.u's to be extracted from the fuel.

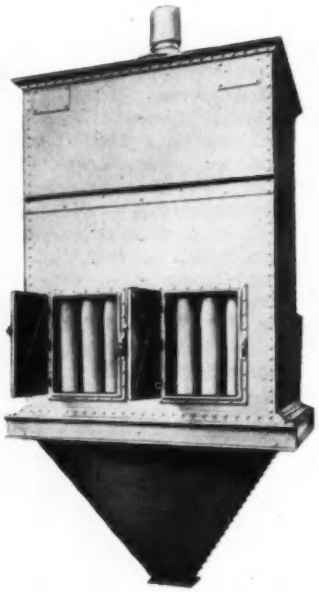
Output ranges

Also on show on this stand were examples of the existing range of 'Counterflo' gas-fired heaters. Models are available with outputs ranging from 400,000 to 1,500,000 B.t.u's per hour.

Other examples of gas-fired heating equipment were shown by **Air Heating Ltd.,** whose range includes models suitable for both direct or ducted distribution, and **Radiant Heating Ltd.** whose overhead heaters have long been firmly established in this field.

There are few factory canteens which do not include at least some

Typical of the overhead gas heaters shown at the Factory Equipment Exhibition was the 'Mastertherm' heater by Radiant Heating Ltd., shown here installed in a factory.



For the first time at any exhibition Keith Blackman Ltd. showed the 'Tornado-Fischer' automatic self-cleaning filter.

items of gas-fired equipment, and one or two firms took the opportunity to show new developments in this direction. **Radiant Heating Ltd.,** for example, showed their gas-fired 'Grillmaster,' which is available in 'Senior' and 'Junior' versions, respectively capable of dealing with 100 and 50 steaks per hour. Economy in gas consumption is obtained by the fitting of patent flameless gas radiant burners which reach incandescence in approximately one minute.

G. F. E. Bartlett & Son Ltd., specialists in the design and manufacture of canteen equipment for well over a century, had mounted a comprehensive display at Belle Vue, including the latest model of their deep fat fryer. This gas-fired unit, which is of pleasing and effective design, incorporates a cool zone below the frying area so that if, during frying operations any particles of batter or very small chips may fall, they drop into the cool zone without burning or spoiling the oil.

Only the thermostat head is visible through the hinged door at the front behind which the burner assembly and all associated controls are sited. Variable control within a range from 220°C. to 410°C. is possible, and the luminous jets are controlled by an interlocking main/pilot gas cock. The unit is effectively insulated and fitted with top rear flue outlet.

A deep fat fryer, with a capacity of 90 lb. per hour, was also shown by **Dowson and Mason Ltd.**

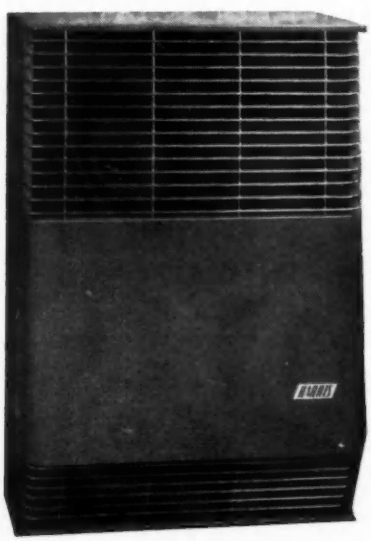
Disposal of waste and rubbish, without creating a nuisance through smoke or smell, often poses a problem to factories. **Radiant Heating Ltd.** showed the new American 'Caloric' automatic gas disposer which is already being widely welcomed by British industry. This attractively-styled incinerator embodies a 'jet stream' action—an airflow system which assures complete combustion of all refuse and draws smoke and smell back down through the combustion tube to be consumed by the gas flame.

Operation of this incinerator is simple. The waste is dropped into the refuse chamber, the lid is closed and locked and a dial set to the desired level, according to the charge requirements. The incinerator has a capacity of 2 cu.ft. and a gas input of 32,000 B.t.u.'s per hour.

Another outstanding incinerator was the new Dowson Morse Boulger 'CT' Destructor, exhibited by **Dowson and Mason Ltd.** This incinerator is offered in four sizes, ranging from the smallest model (4 ft. 4 in. long, 3 ft. 8 in. wide and 5 ft. 6 in. high) to the largest (7 ft. 11½ in. by 3 ft. 8 in. by 5 ft. 6 in.).

As all four models are only 3 ft. 8 in. wide and require only a 4 ft. clean out aisle at the side, this incinerator can be accommodated in a restricted space.

In the 'CT' Destructor the gas burner can be placed either firing into the ignition chamber or combustion chamber. The controls for clearing the hearth are conveniently placed and easily operated. The incinerator is charged by opening a special



The 'Wellsway' Mk 2 flued gas convector heater, a Harris Engineering Co. Ltd. exhibit.

The new American 'Caloric' automatic gas disposer or incinerator, which is already being widely welcomed by British industry, was shown at Manchester by Radiant Heating Ltd.

'Swing-a-Way' door which moves easily upwards to allow access to the combustion chamber. The opening is large enough for charging all sizes of rubbish containers. Removal of residual ash is also a simple matter.

Keith Blackman Ltd. have long been established suppliers to the gas industry, and at Belle Vue their well-appointed stand included a wide selection of their fans, blowers and other equipment for use in connection with gas-fired plant. An industrial gas equipment display included apparatus for low and high pressure and air blast systems covering burning, controlling, compressing and safety equipment. This exhibit included the Company's latest air blast tunnel burner for furnaces as well as an air/gas compressor, mixture controllers and back pressure and cut-off valves.

Undoubtedly the main attraction on the **Keith Blackman** stand, however, were the two pieces of equipment being shown for the first time, namely, the 'Tornado-Fischer' automatic self-cleaning filter and the 'Tornado-Solivore' wet scrubber.

The 'Tornado-Solivore' wet scrubber is designed for collecting fine industrial dusts and fume particles as small as 0.1 micron diameter.

A special feature of the 'Tornado-Fischer' filter is that the amount of maintenance it requires is negligible, and in fact it will function continuously without attention, due to the special design of the filter elements, the type of filter fabric employed and the patented shaking gear.

GAS AT 'FIVE TOWNS' JUBILEE

THE huge swing from solid fuel to gas in the manufacture of pottery is one of the outstanding success stories of the gas industry. In the North Staffordshire Division of the West Midlands Gas Board the demand for gas is breaking records and the gas and pottery industries have been called partners in a revolution which has brought better, cleaner working conditions for thousands of people and literally changed the face of the Potteries.

To drive home these facts to the thousands of people who visited the Stoke-on-Trent Golden Jubilee Exhibition, held in Hanley Park, and to attract possible new business, the West Midlands Gas Board had an impressive stand in the Industrial Section. The exhibition, sponsored by the North Staffordshire Chamber of Commerce, was part of the celebrations marking the 50th Anniversary of the Federation of Stoke-on-Trent, Burslem, Longton, Hanley, Fenton and Tunstall. (Arnold Bennett's famous 'Five Towns' in fact number six.)

Boldly displayed across the centre of the stand was a giant enlargement of a local press advertisement, 'There is a new atmosphere in the Potteries . . . thanks to gas.' That is a message readily appreciated by anyone able to recall the grimy appearance of the Five Towns in the days of the old-fashioned bottle kilns, now replaced in their hundreds by gas-fired kilns.

Flanking this facade were a full-sized cross section of a multi-passage kiln and a model of an intermittent batch type kiln. Striking illuminated colour transparencies around the stand depicted some of the many other industrial uses of gas—a melting furnace for pressure diecasting, shrinking tyres on locomotive wheels, stress relieving, hardening caterpillar tracks, conveyor ovens for paint drying and a controlled atmosphere gas carburising furnace.

In addition to 'firing,' gas is now used on a large scale for drying clay ware and many ancillary processes. This field of operation was illustrated on the stand by a drying unit similar to many gas-heated driers which are rapidly replacing the old-fashioned drier heated by steam from a solid fuel, Lancashire boiler.

The Board devoted a second stand to domestic appliances including a display of small bore central heating, which attracted many enquiries.

One of the Board's clean air cars was also in attendance at the exhibition with coke fires and appliances showing how the private householder can help bring about a better atmosphere.

The expansion of the gas industry in Stoke was also depicted at an earlier exhibition in the Kings Hall dealing with local government in the Potteries over the past 50 years.

Southern industrialists see how gas helps

A four-day exhibition was staged recently in the Southern Gas Board's Industrial Development Centre at Bournemouth when industrialists throughout the Board's very large area were invited to see demonstrations of spraying and stoving and a comprehensive display of the latest equipment. The demonstrations developed into 'Do it Yourself' sessions in many cases.

On arrival, visitors saw a film 'starring' the remarkable Ransburg No. 2 electrostatic spray painting hand gun. After the film, they had the opportunity to examine the application of the process to their own production, and many had brought along samples of their own products for this purpose. They were impressed by the advantages of the method in various fields of manufacture and its undoubted savings in terms of paint, labour, rejects, ventilation and floor space.

Visitors were also able to try their own products in a gas-fired radiant heat tunnel for stoving. The tunnel demonstrated consisted of 12 panels and was fitted with a temperature control by the Industrial Pyrometer Company, together with panel temperature indication by a six point pyrometer supplied by the Electroflo Meter Co., Ltd.

The exhibition was well attended and seemingly much appreciated, particularly because it gave visitors a chance to inspect the new processes brought within easy reach of their factories. Some stayed for several hours to carry out the full operation of spraying and stoving samples of their products. The Southern Gas Board's Industrial Gas Department hope to make it the forerunner of a series covering a variety of processes to which appropriate manufacturers will be invited to send representatives, in addition to the permanent exhibition available at all times in their Industrial Gas Centre.

EXHIBITION MAY BE FORERUNNER OF A SERIES

Manufacturers prominent in the exhibition were Parkinson and Cowan Industrial Products who supplied the radiant heat tunnel and teleflex conveyor system, and Henry W. Peabody who demonstrated the electrostatic coating process.

METAL FINISHING

METAL finishing may appear to be a limited field but on investigation the processes connected directly or indirectly with the finish of metals cover an immense field. In fact it is true to say that we make very little use of metal which has not been subjected to a finish in one way or another. It is possible only to deal in this paper with some of the metal finishing processes in which gas plays an important part.

● **THERE ARE two main reasons for metal finishing, namely—prevention of corrosion, decoration, or a combination of these two.**

Preparatory treatment

The preparatory treatment of metals (or, rather, insufficient cleaning) leads to more difficulties in application of surface coatings such as paint, electroplate, or vitreous enamel than almost any other cause.

The importance of this preparatory cleaning is so great that no excuse is needed for referring to it in the opening paragraphs of this paper. Clean surfaces may be roughly classified under three headings:—

Generally Clean

This means that the major portion of the dirt has been removed, but slight traces are likely to have been left.

Grease Free

This means that the surface is completely oil and grease free but residual traces of scale and surface oxides may still be present.

Chemically Clean

This means that all foreign matter has been eliminated and that the basic material alone is exposed.

Generally, clean surfaces are produced by various mechanical cleaning methods and also by certain chemical cleaning methods such as pickling and grease-free surface by efficient organic solvent degreasing treatment. Chemically clean surfaces are the most difficult to prepare and are usually indicated by their 'wettability' with water, i.e., the water should drain as a continuous film from a vertical surface and not exhibit 'water-break.' They are produced by suitable treatment in chemical solutions, the composition of which vary according to the nature of the base metal and its previous treatment.

The choice of the correct sequence of cleaning processes preparatory to the application of a surface coating is of utmost importance, not only in ensuring the durability of the coating but also in that it is the most economical process possible.

General principle

The general principle controlling the choice of suitable preparatory treatment is as follows:—

(a) When a surface is to be left bright and clean a 'generally clean' surface is good enough.

(b) For those coatings which would be marred by slight traces of grease but which rely more on a mechanical bond rather than on a physico-chemical bond of good adhesion, such as paint or flame-sprayed metals, a 'generally clean' but also a 'grease free' surface is necessary.

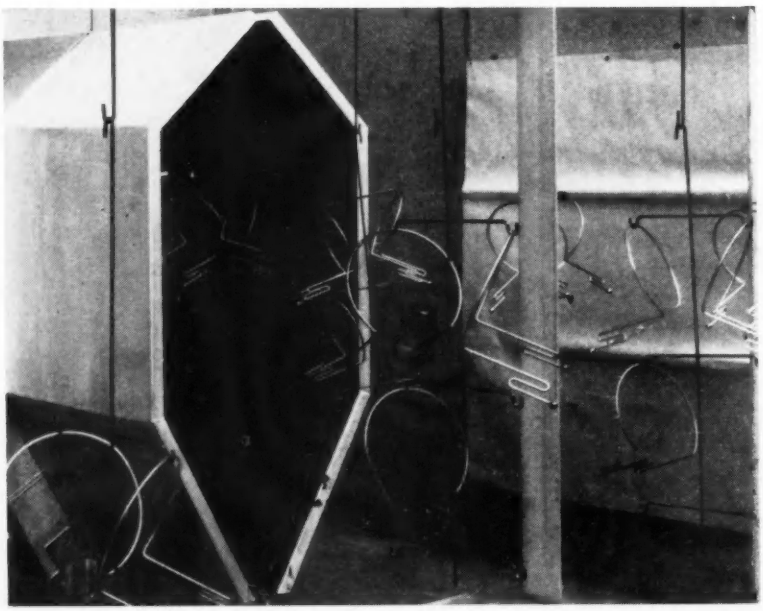
(c) For those coatings which rely almost solely on physico-chemical bond for their adhesion, such as electro-plated metal, then a 'chemically clean' surface is essential.

It is not intended to enlarge on cleaning methods and processes but simply to state the classification and importance.

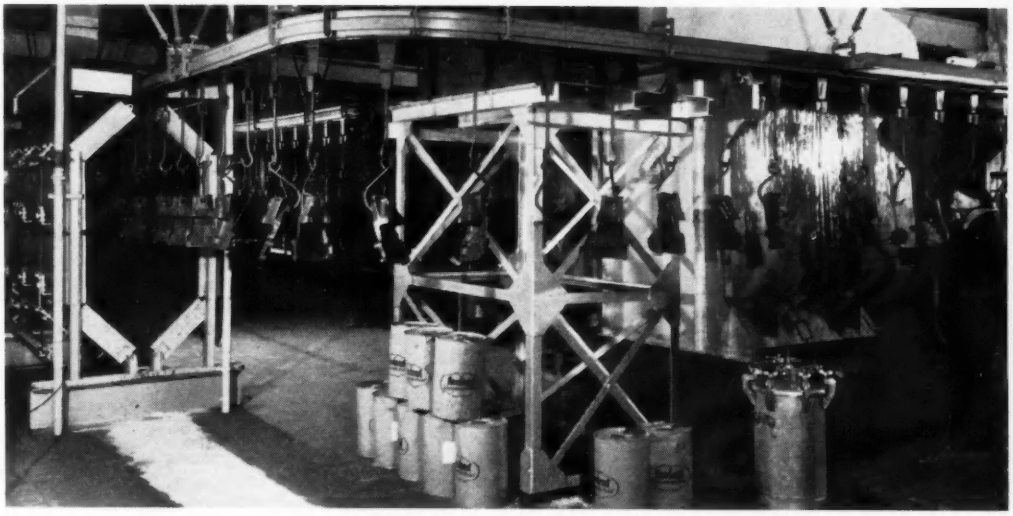
Painting Processes

A most common method of finishing metals is a paint finish. Primarily the use of paint is to protect and the decorative aspect should be of secondary importance, but due to customer sales appeal and the pleasing effects of painted surfaces the decorative reason for using paint is now usually aligned with the primary reason.

When all the requirements of protection have been satisfied, painting may assume a decorative character such as the highly stressed sales appeal type,



Gas-fired infra-red tunnel by Parkinson & Cowan for the stoving of laquered wire stands at the Blackburn works of Jones Textilates Ltd.



Infra-red paint drying of engine parts, Leyland Motors Ltd.

the traditionally high decorative, such as church ornamentation, and the simple utilitarian. The decorative quality of a painted surface depends a great deal on colour for its appeal, but no small part is played by the feeling of quality imparted upon touching or handling a well-finished object. An attribute of a painted surface is that for articles which have to be handled such as metal furniture, bicycle frames, and motor car bodies the surface must be cool and smooth to touch, definitely non-sticky and capable of taking a high grade of polish if needed.

Good paint surface

Included in the attributes of a good paint surface is, of course, colour retention, although the expected life and the type of article has to be taken into account when a paint finish is being planned. It is obviously uneconomical to have an extremely enduring and expensive enamel on an object having a total life of say six to 12 months. On the other hand it is false economy to cut the cost of painting on a highly-priced object which may lead to rejects during manufacture, or complaints by the customer during the life of the article.

Another important attribute of paint is in some instances its non-toxic properties. Children's toys often find their way to children's mouths, therefore the paint used on toys must be non-toxic. Paints must also be non-toxic in the degree that they do not contaminate or taint foodstuffs, although the use of vitreous enamels largely supersedes any normal finish for vessels which are likely to contain food except in the canning industry.

The constituents of the primer paint are decided by the type of metal (e.g., red lead would not be applied to aluminium) the length of time the article will remain with only the primer paint application before the finishing paint surface is applied and the type of final finish.

Paints consist of three main constituents:—

Volatile

Solution.

Vehicle

Binds pigment to surface, provides adhesion, film hardness and protects against corrosion.

Pigment

Resists corrosion and gives desired colour finish.

Governed by finish

The type of paint is governed by the finish required, the time available for the paint to be 'flashed-off,' the location of the finished article (whether inside or outside) and the time available for either stoving or infra-red treatment.

The original method of paint drying was that of air drying and the articles were completely at the mercy of the weather conditions, workshop heating and dust conditions.

The introduction of forced drying ovens, stoving ovens and infra-red equipment has eliminated these varying conditions and also they have speeded up the process immensely.

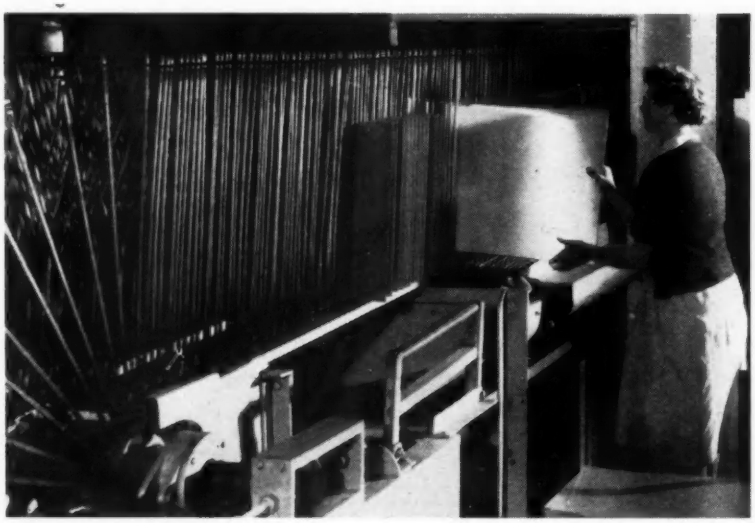
Stoving is a most satisfactory way of paint drying, particularly in view of the fact that both the finish and durability of the finish are improved. Stoving involves heat transfer from the heat source to the coating or paint film.

Operating temperature

The articles are either dipped in a paint bath or sprayed by means of a paint gun and are loaded in a triple cased gas-heated box oven or passed through a gas-heated stove on a continuous belt or suspended from an overhead moving rail. The operating temperature is entirely decided by the type of paint being used and the finish required, and varies over rather a large range. The desired stoving temperature is obtained in some installations by means of non-aerated gas burners placed below the oven and the hot products of combustion being allowed to pass between the inner and outer casings, or by externally mounted air heaters complete with fans and suitable ducting.

This method of stove enamelling is most suitable for all types of articles,

A paper presented to the 10th General Meeting of Industrial Gas Engineers by S. Heywood, Assoc.M.Inst.Gas E., A.M.I.Mech.E., Industrial Engineer, Preston District, West Lancashire Group, N.W.G.B.



Stoving lithographic tinplate in a gas-fired oven at R.D.M. Closures Ltd.

particularly those of irregular shape and of varying surface to weight ratio.

A plant for the stove enamelling of copper wire developed from an existing installation by the North Western Gas Board, Liverpool Industrial Development Centre, is of particular interest. Each oven was capable of processing simultaneously 144 continuous strands of copper wire measuring from 0.03-0.10 in. diameter. The ovens were vertically constructed of lightweight refractory insulation, and measured 30 ft. high × 6 ft. 6 in. wide × 1 ft. 6 in. deep. The stoving chamber consisted of a vertical slot 4½ in. wide running the full height of the oven. The wires were carried on individual guide pulleys mounted at the top and bottom of the oven. The wires travelled from the bottom to the top of the oven.

Enamels used

The enamels used were either oil-based enamels requiring an oven temperature of 450-600°F. or alternatively cresylic acid base synthetic resins requiring processing temperatures of 600-900°F.

The copper wires processed were given a moderately ductile surface finish of light electrical resistance suitable for windings on electric motor armature field coils, transformer coils, etc.

The original installation incorporated a rather involved system of combined up-draught and down-draught gas firing with cast iron heat exchangers within the oven. The objections to this system were that they were uneconomical, each oven required a heat input of 4-4½ therms per hour, and alternative fuel was being considered. The original ovens required 48-60 hours to obtain a satisfactory enamelling temperature after a shut down, distortion of the cast iron heat exchanger enabled flames to enter the stoving chamber causing ignition of the enamelling solvents with resulting fires, and the oven temperatures never reached above 650°F.

Heat transferred

Investigations showed that where the length to diameter ratio is great, radiant heat transfer became insignificant in comparison with the quantity of convective heat transferred. It was, therefore, decided that the system of heat applied to the oven should be one of forced convection, the hot air flow being contra-flow to the travel of the wires.

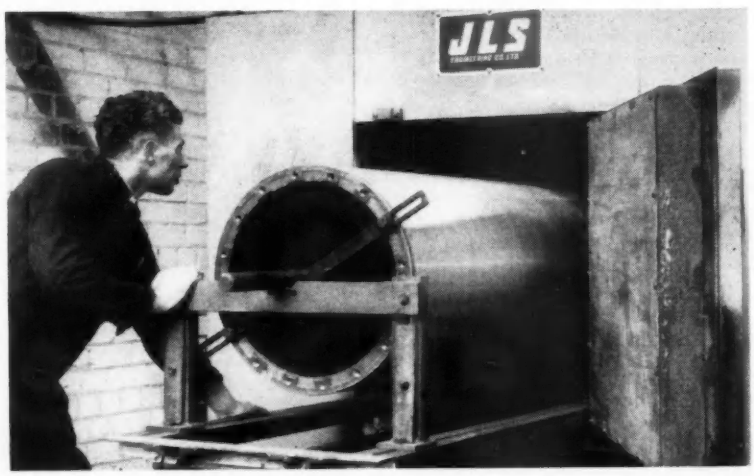
An Axial Jet Type M air heater was mounted on the top of the oven and by means of suitable diffusing nozzles on the heater outlet, the hot air was ducted into the top of the oven. Complete uniformity of temperature was obtained across the width of the oven.

It was found that for a heat input of 2.7 therms per hour (i.e., a 40% reduction in original gas rate) approximately 70% more wire can be processed and the ovens can commence the process of enamelling within 30 minutes of relighting from cold. Recirculation principles are being developed which should reduce the gas consumption per oven to approximately 1.25 therms per hour.

Crown cork

Tin printing is the name applied to the process of printing a paint design on sheet metal used in the manufacture of such articles as trays, children's sand buckets, fancy boxes, drums, etc., and the paint design is often stoved in the continuous type of stoving oven. Whether the choice be lemonade or beer, very few people will be aware of the care and attention given to the manufacture of the bottle sealing cap, or crown cork, which is the correct name for this patent seal.

In the works of R.D.M. Closures Ltd., will be found crowns lithographed with many familiar names both national and international, and several million of these crown corks are turned out each day. Standard sheets of South Wales tinplate, printed to produce 288 crown blanks, are passed through lithographic printing machines and heat treated by gas heated conveyor ovens which are accurately controlled in two, three or four zones to maintain stoving temperatures between 250-350°F. After printing, the sheets are pressed to the crown shape, and are then ready for



Gas-fired air recirculation oven by J.L.S. Engineering Company, for the baking of P.T.F.E. finish at the Darwen Works of Hibbert & Co. Ltd.

the Portuguese granulated cork disc to be inserted.

Paint drying can also be carried out most effectively by the use of gas-fired infra-red heating units. In the investigation of the energy distribution in the spectrum of a hot body it was found that the maximum heat energy occurs in the region just beyond the red end of the spectrum. These invisible radiations of wave lengths longer than 7,600 A are termed infra-red radiations. They can be reflected by polished mirrors and refracted by rock-salt prisms according to laws similar to those for light radiations.

Infra-red radiation is employed for drying moulds, baking cores, drying paints and stoving lacquers, etc. The introduction of the gas fired infra-red heat sources operating at medium temperatures which are easily controllable to suit any particular process opened new fields of application for this form of heating as applied to paint drying and other industrial applications. The distribution of wavelengths over which the radiation from these sources takes place is such that there is little difference in the rate of heating whether the article to be treated is matt black (usually the best for absorbing radiation) or any colour matt or glossy. The speeding-up of operations which characterises this form of heat application is entirely due to the fact that there is no resistance to heat transfer from the radiating panels to the work.

'Skin-effect' absent

The 'skin-effect' which lengthens time of heating in convection processes is absent. For example, a sheet of 16 S.W.G. mild steel in a convector oven at 300°F., when exposed to the radiation from the walls of the oven took 2.8 minutes to reach a temperature of 220°F., while in an infra-red unit the same sheet reached this temperature in 1.25 min. When the sheet was placed in the convector oven with other work which shielded it from the radiation from the oven walls, the time taken was 7.6 min. The time required to heat up work depends on size, material and weight. Light gauge metal sheets can be heated up in a matter of seconds, heavy castings may take 30 min., but in most cases the time for infra-red heating is a fraction of that required by other processes. The length of tunnel required for a particular installation depends on the time of treatment required and speed of production, the latter factor of course controlling conveyor speed where conveyors are used. The maximum temperature of the radiant panels is approximately 650°F., and practically uniform over the entire radiating area of the panels. The heating times at this temperature for 22 s.w.g. and 6 s.w.g. are given in the following table:—

Wire galvanising bath, heated by recirculated hot air at Firth Company.

Time	S.W.G.–22 in °F.	S.W.G.–6 in °F.
0 sec.	70	70
10 ,,	140	—
15 ,,	175	85
30 ,,	240	100
45 ,,	300	114
60 ,,	335	130
1½ mins.	390	160
2 ,,	410	195
2½ ,,	425	225
3 ,,	430	250
4 ,,		290
6 ,,		344
8 ,,		390
10 ,,		417

Details of gas-heated infra-red heating installations are given below:—

(1) *Articles treated*—10 gauge metal index plates.

Paint used

(a) Consumer's own paint.

(b) Donald Macpherson's heat transformable blue.

Heating cycle

(a) Red priming coat stoved 3 min. with a panel temperature of 650°F., followed by grey top coat 3 min. at same temperature.

(b) Blue under-coat stoved for 2 min. at a panel temperature of 650°F., followed by a top coat stoved for 2 min. at the same temperature.

(2) *Articles treated*—Jerry cans.

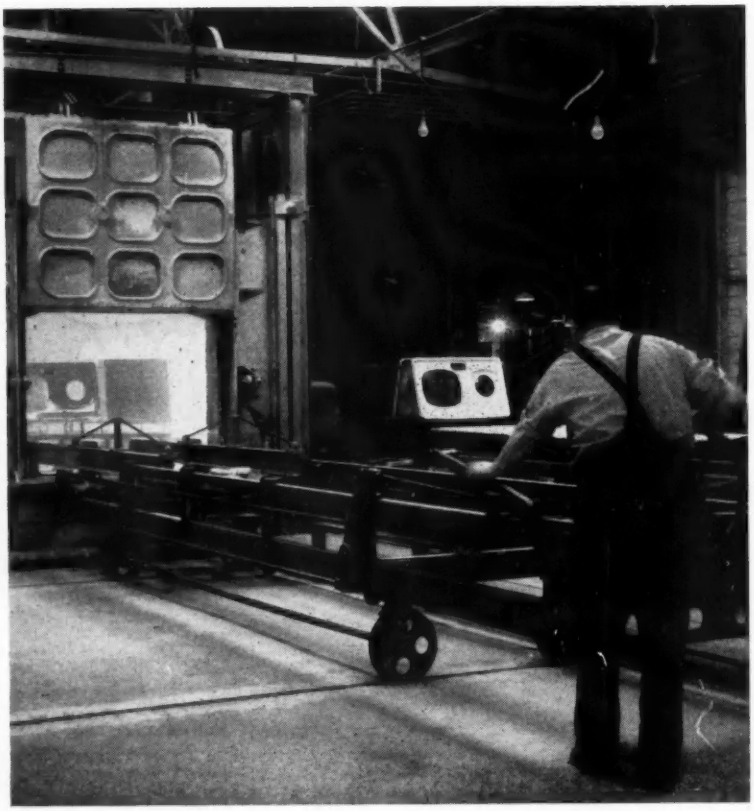
Paint used

(a) Glasso half-hour combination enamel.

(b) Internal jerry-can enamel.

TEMPERATURE REQUIRED IN ELECTRO-PLATING BATHS

Metal Plate	Nature of Bath	Temperature °F.
Brass	Cyanide	90–115
Cadmium	Alkaline	70–90
Chromium	Acid (chromic)	105–125
Copper	(*a*) Acid	80–125
	(*b*) Alkaline	95–105
Gold	Cyanide	104–180
Nickel	Sulphate	70–90
	Sulphate & Chloride	125–140
Silver	Silver Cyanide	60–80
Zinc	Zinc Sulphate	70–140
	Zinc Chloride	70–105
	Alkaline Zinc Cyanide	105–125



Radiant tube vitreous enamelling furnace by The Incandescent Heat Co. Ltd., recently installed at Blakes Vitreous Enamelling Ltd., Clayton-le-Moors.

Heating cycle

(a) Stove for 30 secs. with a panel temperature of 650°F. A coating of this enamel was applied to an under-coating of the same material which had been stoved at 650°F. for 70 secs.

(b) Stove for 2 min. with a panel temperature of 650°F.

An attraction for the modern table is the support of culinary dishes on wire stands, many of which are gilt plated and in some cases incorporate small heating lights to keep the contents warm.

Lacquering

To preserve the gilt plating the stands are dipped in a clear lacquer and afterwards dried by passing through a 9-ft. long gas-fired infra-red tunnel for a period of 9½ min., a process which could otherwise take many hours.

Infra-red heating has a wide field of application. The essentials for successful application of infra-red heating are that all objects to be heated must have about the same surface to weight ratio, be capable of receiving the radiation over the major part of their surface and have a sufficiently high conductivity to carry the heat to parts shielded from radiation. If the temperature of convector ovens is raised they tend to give similar results in speed to the infra-red tunnel, but care must be taken that the objects near the walls are not spoiled by infra-red from the walls.

Vitreous enamelling

With the continuous development of materials for vitreous enamelling, the production of sheet metal of suitable quality, and the introduction of mechanised methods of application, this type of finish has become popular on account of its durability, attractive appearance and easily-cleaned surface. Vitreous enamelling is, in effect, the application and fusing of a tough glass to a metal, usually cast or sheet iron and sheet steel. The constituents of a vitreous enamel are an alkaline silicate or borate, to form the enamel glass or 'frit,' a pigment to give tint and opacity and if necessary an addition agent for modifying the fusing characteristics.

The enamel is made up either by intimately mixing the constituents for direct application to the surface or by fusing them together, then regrinding to a fine powder which is added to water to form 'slip.' Dry powder is applied by dusting or dipping the work at approximately red-heat temperature; slip is applied by dipping, spraying or brushing. After drying, each coat is fused at a temperature of from 700-900°C. in a muffle furnace.

A recent development is the gas-burning radiant tube furnace in which the muffle chamber approximates to a heat insulated box. An installation of this type of furnace has recently been erected by the Incandescent Heat Co. Ltd. in the works of Blake Vitreous Enamelling Ltd. at Clayton-le-Moors, Accrington. The furnace is heated by 10 Jetubes arranged five at each half of the furnace at approximately 2 ft. 6 in. centres. Town gas is supplied at a pressure of 14 in. w.g. and the fan pressure air is at 16 in. w.g.

Complete combustion

The air and gas mix together at each burner head, from which the mixture is injected at high pressure into the combustion chamber where complete combustion takes place. From this combustion chamber a special jet nozzle discharges the products of combustion into the Jetube proper at great velocity causing an increase in both the velocity and temperature of the surrounding gases in the tube which in turn induces recirculation of the mass of gases in the tube.

The gas velocity in the tubes is much greater than that which could be obtained if the gases injected at one point and exhausted at another after a single pass. Since the gases are intimately mixed localised hot spots are completely eliminated, and the high mass flow obtained from the gas gives high heat transfer rates and ensures rapid heating of the furnace to working temperatures as well as rapid heat transfer to the work with which the furnace is loaded.

Hermetically sealed

The whole Jetube system being hermetically sealed ensures freedom from contamination of furnace atmosphere by products of combustion, whilst the uniformity of temperature gives correct fusing of widely varying types of frit.

The dimensions of the 'Jetube' furnace are 5 ft. 6 in. wide between the tubes, 12 ft. 6 in. long and 4 ft. 3 in. high from the top of the landing walls to the underside of the crown of the arch. The doorway opening is 5 ft. 0 in. wide and 3 ft. 6 in. high. The maximum gas rating is 5,000 cu.ft. per hour (22.5 therms).

This furnace, so far, has been confined to the firing of flat sheets, being tops and sides of domestic washing

machines and refrigerators. The gross load (i.e., the weight of the sheets plus weight of burning tools) has varied from 170 lb. to 220 lb. per loading, the net weight of sheets varying from 91 lb. to 104 lb. Tests show gas consumptions of 0.007 therms per lb. on the gross loading and 0.02 therms per lb. on the net loading. An important benefit of the Jetube furnace is its high recovery rate. For example, to raise the temperature from 820°C. to 850°C. requires 40-45 min. in a normal type of furnace whereas the Jetube requires approximately 10 min. A similar advantage obtains when it is required to reduce the temperature.

Galvanising

The effective prevention of corrosion and red rusting in particular, to which ferrous metals are prone when subjected to exposure to water, moist atmospheres, saline solutions and contaminated atmospheres is one of utmost importance.

Galvanising achieves this object and consists of a process of applying a coating of zinc to the surface of the iron or steel to provide a corrosion-resisting surface.

Essentially the hot dip galvanising process consists of the immersion of the iron or steel in a bath of molten zinc at a temperature of 460-480°C. The article is left immersed for a sufficient time to allow initiation and completion of the electro-chemical reaction between the zinc and the iron. The article is slowly withdrawn from the bath, this movement being one of the chief factors governing the thickness of the coating. Various preparatory treatments are required to render the surface of the iron or steel completely clean before it is immersed in the molten zinc.

Preparatory treatments

The preparatory treatments include de-scaling, de-greasing, pickling and fluxing, the first being necessary to produce perfectly clean surfaces, and fluxing is necessary to prevent oxidation taking place before the articles can be immersed in the molten zinc bath. Fluxing also performs another necessary function, that of cleansing the two reacting surfaces of the iron and molten zinc at the point of immersion.

Many varied articles such as steel window frames, steel strip for roofing, mild and high carbon steel wire, etc., are subjected to a galvanising treatment. Thompson Bros. (Bilston) Ltd., installed a setting at Chester for galvanising steel window frames. They estimated the life of the pot to be in the region of eight years, and after more than four years no sign of pot failure is apparent. Details of this setting are:

Size of Pot

11 ft. 6 in. long × 3 ft. wide × 7 ft. 6 in. deep containing 45 tons of spelter and 1½ in. layer of lead.

Type of Setting

Partly sunk in the floor. Burners all round pot firing up and over refractory baffle wall.

Burners

20 post-aerated gas burners, drilled pipes, slot firing each individually controlled by quadrant cock.

Flue

Horizontal under longitudinal centre of pot bifurcated thereafter under floor of flux drying oven. Mechanical extraction normally and natural draught when on stand-by.

Control

Foster three-point recorder-controller so arranged that gas consumption is reduced whenever either the spelter temperature reaches 455°C. or the flue temperature reaches 580°C.

Output

Normal working at the rate of 30 cwt. per hour maximum obtainable by forcing 55 cwt. per hour.

Wire galvanising

The galvanising of steel wire is a continous process. In a typical installation, up to 40 wires or 'ends' are simultaneously and continuously passed through a preheat and then into a lead bath to effect annealing. After leaving the lead bath the wires pass through a washer before entering the acid tank for the cleaning and pickling operation. From the acid tank the wires pass through a washing tank to remove all traces of acid. Finally after passing through the flux and a preheat they enter the galvanising bath.

The wires leave the galvanising bath fully galvanised to the winding frames situated above the bath so that the wires leave vertically. The preheating chambers and lead baths are mainly heated indirectly by the hot flue gases from the galvanising bath.

The speed of the wire is approximately 70 ft. per minute and the total gas consumption of a plant capable of galvanising 40 wires is approximately 9,000 cu.ft. per hour.

Metal spraying

This process is used to protect steel or other metals against corrosion and so enable them to withstand the effect of heat, atmosphere, chemical fumes, etc. It is also extensively used for the building up of worn parts.

It is a process in which a fine spray of molten metal is projected on to the surface of an article which can be of any shape or size. The articles can be sprayed either before or after prefabrication and there is no danger of distortion. The spray coating also provides an excellent key for paint where it is required for decorative purposes. There are three distinct types of metal spraying appliances in which the metal to be sprayed is introduced in the form of metal wire, metal powder and molten metal.

All surfaces to be sprayed must be carefully prepared. All foreign matter such as scale, rust and grease must be removed and the surface roughened to form a key. Good adhesion of the sprayed metal is dependent upon the correct preparation.

(To be continued)

COLOURING PROCESSES

Metal	Coating Colour	Solution	Temp. °F.	Immersion time
Copper ..	Terra-cotta brown	Copper Acetate Copper Sulphate	108	3–5 secs.
Brass ..	Umber brown	Barium Sulphate	128	5 secs.
Brass ..	Oak brown	Sodium Hydroxide Ammonium Hydroxide Antimony Sulphite	160	
Aluminium ..	White	Principally lime	185	10–240 min.
Aluminium ..	Yellow Gold	Potassium Permanganate Copper Sulphate	186/ 190	20 min.
Aluminium and alloys..	Velvety grey	Phosphate and Manganese Phosphate	Above 212	
Aluminium ..	Deep brown	Nitric Acid and Chemical Salts	180	10–15 min.

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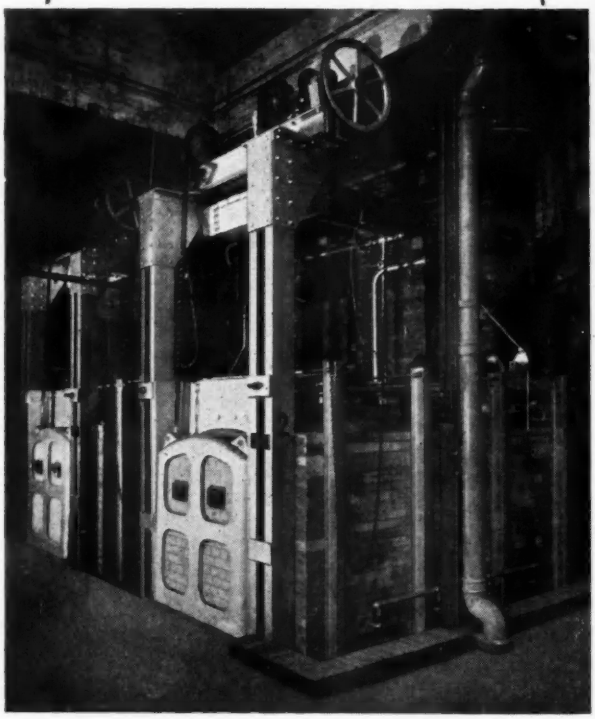

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